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REPORT OF THE COMMITTEE ON OCULARS.

Dr. R. H. Ward, Chairman of the Committee, consisting of R. H. Ward, H. L. Smith, J. D. Hyatt, Geo. E. Blackham and Jacob D. Cox, called up the Report* on Oculars, which had been lying on the table since the last meeting, with the following remarks:

Your committee on nomenclature and sizes of oculars, with the concurrence of your present President, Hon. J. D. Cox, who was added to the committee last year, desire to call up for your consideration the proposals made at that time, without material alteration. Having been very judiciously allowed to lie over for a year, their details are sufficiently familiar, and members have had ample time for consideration, discussion and decision in regard to the several points involved. It will be noticed that the report comprises two wholly independent proposals, either of which may be adopted or rejected without regard to the other.

1. *The naming of oculars, like objectives, by their equivalent focal lengths in inches, but estimated in a conventional manner at a somewhat arbitrarily chosen distance.* This is an attempt to secure in the case of oculars an approximate and serviceable nomenclature having somewhat of the practical convenience of that in use for objectives, which shall imply a reasonable suggestion, not claiming to be a precise statement of the power employed. Though not free from criticism, our nomenclature of objectives has been used, and continues to be used, with some satisfaction; and it is conceded to be the best plan yet brought into actual service. It has been already applied to oculars by several makers and by many users; and it is simple and so in accord with present usage and habits as to seem scarcely an innovation, and to be capable of adoption without conscious effort or sacrifice. The only other plan seriously proposed, naming by numbers representing the actual magnifying powers, has long ago been tried and abandoned by most competent authorities. It involves such extreme changes of ideas and habits in thinking and speaking of oculars and objectives, that there is great doubt as to the practicability of securing its early adoption.

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*Chicago meeting, page 175.

Nor is it certain to be advantageous if adopted. It lacks the simplicity which in the other case classes the powers in a limited number of familiar groups, and introduces an indefinite number of names marked by larger figures, clumsy to use and difficult to remember and not so easily suggestive of their practical significance. It also involves the claim for a precision which it does not possess; since the complications of collar adjustment and tube-length, which only somewhat impair the value of the approximate method, seem as yet wholly incompatible with a more precise system. Furthermore, the nomenclature by inches would be so easy a movement in the direction of sensible method, that it might prove to be a step toward rather than from any further improvement that might prove desirable.

It is not claimed, and has never been supposed, that the proposed method of measurement would give results exactly corresponding with the optical values of the oculars as computed by the Cross formula, or any other. Nor does it seem certain that persons not opticians can locate the focal planes of their objectives and oculars with such ease and precision as to secure in each case a tube-length that would work the various systems exactly at their theoretical power, or that such varying tube-lengths if secured would be within the limits of a convenient working length.

For these reasons it was suggested to establish a conventional nomenclature, representing as nearly as possible the working value in the microscope as actually employed, without regard to their value under other circumstances. By this plan a ½-inch system would be one which *as used in the microscope* would double the power when substituted for a one inch, and a two inch would be one which would give one-half the power of a 1-inch. This is deemed to be an experiment for the purpose of obtaining, at least temporarily, approximate results that would be an improvement on the present practice, in the course of which it is assumed that difficulties will be encountered and intelligent work become necessary, especially in applying it to oculars of exceptional construction. The estimate of powers, on the ten-diameters rule, would evidently cease to be fairly approximate in relation to objectives of very low power, unless a similar nomenclature should be applied to the objectives also. If the proposed method of measuring the powers of oculars prove impracticable or undesirable, the effort may, at least, lead to the discussion and adoption in some form of the nomenclature by inches, which is the essential portion of the proposition. It remains for the Society to say whether it is prepared to take the responsibility of trying the experiment or not.

2. *The selection of 1.25 inch as the Society standard size of ocular.* No objection has been raised to this size, which is believed to represent the average in most favor among members. It is believed to be capable of adoption with as little inconvenience as any other size; and that its adoption will ultimately prove a convenience and advantage to all. As it is improbable that all stands will be adapted to one average and preferable size, larger and smaller figures are suggested as secondary choices. A size of ocular cap-tube is proposed, for the ready interchange of camera lucidas, etc., which could evidently be adopted without optical sacrifice in all oculars whose eye-lenses come within that limit of size. In connection with the standard size of ocular, the 1½-inch substage, which is already in very general use, is proposed as a standard almost universally applicable, easy of adoption, and of considerable importance in allowing interchange of substage apparatus.

APPENDICES.

1. After some informal discussion and suggestions, the Resolutions proposed were put to vote and unanimously adopted, as follows:

Resolved, That this Society recommends that oculars be named by the equivalent focal lengths, in English inches, representing their actual power in use in the compound microscope, with objectives of not more than ¼ inch equivalent focus and with a working tube-length of ten inches including the mounting of the objective, on the basis of one inch focus corresponding to ten diameters of amplification.

Resolved, That this Society recommends the adoption of the diameter 1.25 inch as a standard size of ocular tube, with a preference of 1.00 or 1.35 inch where other sizes are required, and 0.75 inch for ocular cap-tubes, and 1.50 inch for substage tubes, all outside measure.

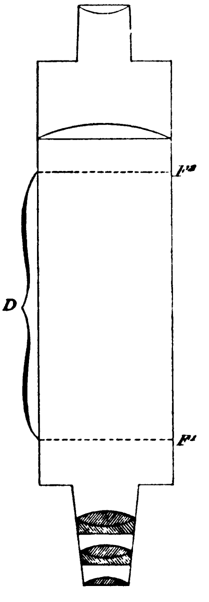
2. In the following extracts from a paper by Mr. Frank Crisp, in the *Journal of the Royal Microscopical Society* for December, 1883, the

relation of optical to mechanical tube-length and to the problem of computing magnifying power is very clearly explained.

"To determine the focal length f of the entire microscope, having given the focal length f^1 of the objective and the focal length f^2 of the eye-piece, * * * the true formula is not

$$f=\frac{f^1 f^2}{10};\ \text{but}\ f=\frac{f^1 f^2}{D};$$

D being the distance between the posterior principal focal plane of the objective, and the anterior principal focal plane of the eye-piece, or, as Professor Abbe terms it, the rational or optical tube-length, in contradistinction to the mechanical or physical length. (The principal focal planes are the planes passing through the point on the axis in which parallel rays coming from the opposite side of the lens are brought to a focus.) The accompanying figure where F^1 is the posterior focal plane of the objective, and F^2 the anterior focal plane of the eye-piece, will illustrate this more clearly.



"By the different methods of construction adopted by their makers the focal plane of one objective may be further off the back lens than is the case with the other [of the same focal length.] The distance D between the focal planes of the objective and eye-piece will be correspondingly diminished, and the focal length of the whole microscope increased. The magnifying power will therefore be diminished.

"Again, take the case of two objectives of say $\frac{1}{8}$-inch and 1-inch focal length used with the same eye-piece (2-inch) and tube. If the distance D remained constant, say 10 inches, the total focal length would vary with that of the objectives.

$$f=\frac{\frac{1}{8}\times 2}{10}=\frac{1}{40},\ \text{or}\ f=\frac{1\times 2}{10}=\frac{1}{5}.$$

But the posterior focal planes of the two objectives, instead of coinciding, may have different positions, every variation producing, of course, a change in the value of *D*. With the $\frac{1}{8}$-inch objective the posterior focal plane may be very near the back lens, and we have a long *D*; with a 1-inch objective its posterior focal plane may be further from the back lens (higher up the tube), and we have a diminished *D*. We might have with the $\frac{1}{8}$-inch objective $D = 10$ inches, and a power of $80 \times 10 = 800$, but with the 1-inch objective we should not have $10 \times 10 = 100$, or a total power in proportion to the powers of the objectives. *D* might be 8 inches only instead of 10 inches, and the total power would be only 80.

"The converse case of different eye-pieces with the same objective is similarly explicable. The anterior focal planes of the eye-pieces may be at different points of the tube and we shall have a varying *D*. * * It may be noted that the position of the anterior focal plane of the eye-piece does not vary much in the Huyghenian form. * * With the objective, however, a very wide range is possible. * * Practically, however, with objectives of ordinary construction, the difference of position of the posterior focal plane is not great with powers higher than $\frac{1}{2}$-inch, and it is only when we come to the lower powers that the difference is a substantial one."

3. While these sheets are in the press, Mr. E. Gundlach publishes the following suggestions on this subject in the *American Monthly Microscopical Journal* for November, 1884.

"Let *m* represent the magnifying power of a lens, *v* the distance of distinct vision, or focal length of the eye, *f* the focal length of the magnifier, and we have the formula:

$$m = \frac{v+f}{f};$$

according to which the magnification of a lens of 1-inch focal length, for instance, the focal length of the eye being taken as 10 inches, would be 11 diameters, not 10 diameters, as is commonly supposed. The magnifying power of a 2-inch lens would be 6 diameters, that of a 10-inch lens would be 2 diameters, and a 20-inch lens $1\frac{1}{2}$ diameters. A $\frac{1}{2}$-inch eye-piece magnifies the image of the objective 21 times (linear), a 1-inch 11 times, and a 2-inch 6 times.

"In determining the magnifying power of objectives * * if m be the magnifying power, t the tube length, and f the focal length of the objective, then we have this formula:

$$m = \frac{t-f}{f};$$

according to which a 1-inch objective, for instance, will, with 10 inches tube-length, give an image magnified 9 diameters, and not 10 as is commonly supposed. A 2-inch will magnify 4 diameters and not 5. Having now found the correct formula for the computation of the magnifying powers of both the objective and the eye-piece, it is a simple matter to properly combine them to a complete and correct formula for the computation of the magnifying power of the compound microscope, which is:

$$m = \left\{\frac{t-f^1}{f^1}\right\} \frac{v+f^2}{f^2};$$

in which m is the magnifying power of the compound microscope, f^1 the equivalent focal length of the objective, f^2 the equivalent focal length of the eye-piece, t the tube-length, v the distance of distinct vision or focal length of the eye. According to this formula a combination of a 1-inch objective with a 1-inch eye-piece will, at 10 inches tube length, give a magnification of 99 diameters, not 100, as is commonly supposed. A 4-inch objective combined with a 2-inch eye-piece will magnify 9 diameters, not 12.5."

NOTE.—In this figure, the eye-piece is represented as a positive one, having the focal plane in front of the field lens, but in the ordinary Heyghenian eye-piece, or modification of it, as generally used in the microscope, the focal plane is situated (or should be) at the diaphragm, between the eye and field lenses. With high power objectives the focal plane (F^1) will be very near the back surface of the posterior combination and within the mounting of the objective. H. L. S.